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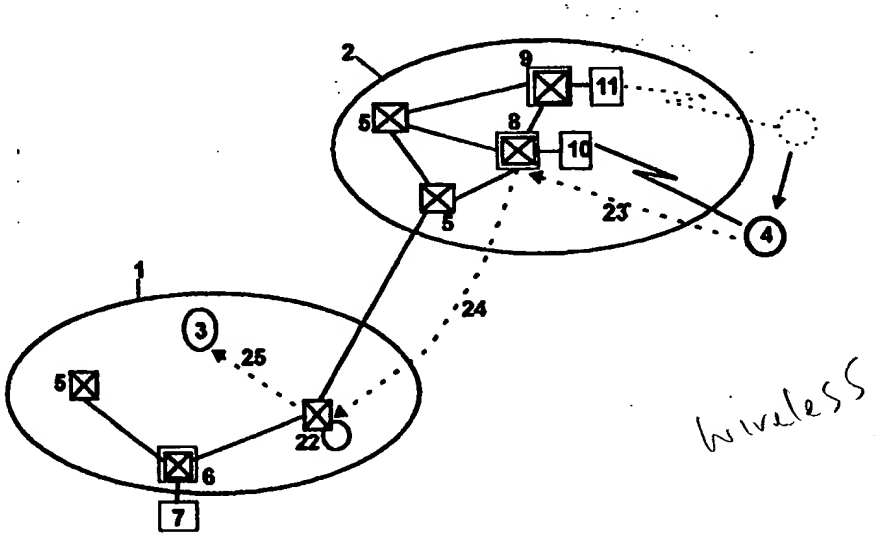

(57) Abstract

An ATM network, adapted to support mobility of Mobile Terminals (MT) at ATM end points includes: a number of mobile terminals; a core network of ATM switches; mobility management means including a Location server (LS); at least one mobility enhanced ATM switch (MAS) having an Access Point (AP) for providing radio connectivity between MT and network; and at least one ATM Roaming Server (RS). The RS is, e.g., an ATM switch having a location server associated therewith, for handling location updates for roaming MTs, or mobility in the ATM network. Thereby reduction in the signalling load on the MT's home network is effected. The ATM RS includes a database for storing a network address for the LS, mappings between network addresses and temporary adresses for each MT, and an address of an authentication server. The database is updated when the MT first moves to and registers with, another network.

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IMPROVEMENTS IN, OR RELATING TO, ATM MOBILE NETWORKS

The invention relates to a mobile Asynchronous Transfer Mode (ATM) network having an ATM Roaming Server (RS), a method for handling mobility in an ATM network, and an ATM Roaming Server for an ATM mobile network.

The Wireless ATM Working Group (WATM) is currently giving consideration to a location management architecture to support roaming in ATM networks. In essence, one faction within the WATM-group is advocating a solution similar to Mobile IP (Internet Protocol) and the other side is advocating a more PCS (Personal Cellular System)-like system with location registers. Two ATM Forum Contributions, namely, (a) A. Acharya, J. Li, D. Raychaudhuri, "Primitives for Location Management and Handoff in Mobile ATM Networks", ATM Forum Contribution, 96-1121, August 1996, and (b) A. Acharya, J. Li, D. Raychaudhuri, "Signalling Syntax Extensions for Location Management in Mobile ATM", ATM Forum Contribution, 96-1624, December 1996, propose location management mechanisms (the so called M-PNNI) which associate a Mobile Terminal (MT) with a home access ATM switch, i.e. an End user Mobility supporting ATM Switch (E-MAS). In essence, a M-PNNI (Mobile Private Network to Network Interface) is a PNNI (Private Network to Network Interface) which has been upgraded to handle mobile users, for example, handover and roaming functionality. PNNI is a protocol specified by the ATM Forum which is used by the switches in an ATM network. Each time the MT roams, i.e. changes access switch, the new location of the MT is notified to the home access switch via a previously set-up Virtual Circuit (VC), which is called the roaming VC in this patent specification. When the VC is set-up, the MT is authenticated with the home access switch.

Use of the foregoing location management mechanism in a roaming scenario, in which a Mobile Terminal (MT) moves from its home network to a visited network, is likely to give rise to the following problems:

- the VC from the MT to the home access switch does not involve the visited network in the authentication process, neither between the visited network and the MT, nor between the two networks;

- the roaming VC either occupies resources, for example, as a real time-VBR, or the signalling over the roaming VC has no delivery guarantee, for example, using UBR;

- handover of the roaming VC is required each time the MT changes access switch;

- distribution of the MT's associated data, for example, location data, service profiles, authentication data etc., to each MT's home access switch, increases the load on the management mechanism.

It is an object of the present invention to provide an ATM mobile network architecture, which is adapted to control the signal load that occurs in a home network of a Mobile Terminal (MT) when the MT visits another network (roaming), through use of an ATM Roaming Server (RS).

It is another object of the present invention to provide a method for handling mobility in an ATM network.

It is another object of the present invention to provide an ATM Roaming Server for use in an ATM mobile network having an ATM Roaming Server (RS).

According to a first aspect of the present invention, there is provided, an ATM network, adapted to support mobile ATM end points (Mobile Terminals), including a number of Mobile Terminals (MTs); a core network of ATM switches; mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location

resolution; at least one mobility enhanced ATM switch (MAS); and an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, on the radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability, characterised in that said ATM network includes at least one ATM Roaming Server (RS) adapted to handle location updates for a roaming MT, thereby effecting a reduction in the signalling load on said MT's home network.

The said at least one ATM RS may be adapted to handle mobility in said ATM network.

The said at least one ATM RS may be adapted to enable a MT to visit, and roam within, another ATM network, without significantly increasing the signallmay be adapted to facilitate inter and intra mobility for access networks that do not have mobility management with location update for roaming MTs.

The said at least one ATM RS may include an ATM switch having a location server associated therewith. The said at least one ATM RS may also include a database adapted to store a network address for said LS, and mappings between network addresses (home addresses) and temporary addresses (visited network addresses) for each of said MTs. The database of the said at least one ATM RS may be adapted to store an address of an authentication server.

Each MT may include a database adapted to store data relating to a network address for an ATM RS with which a respective MT is associated, and the MT's network address (home address), authentication key and access rights. The home address may include data concerning a MAS, in the MT's home network, with which the MT is associated. The database of each MT may be adapted to store temporary data, including the MT's current address, current LAC and current RP_id.

The LS may include a database adapted to store data for each MT, and the network may be adapted to update the database of said LS with the location of a MT when the MT first moves to, and registers with, another network; the database of said at least one ATM RS being adapted to store subsequent location updates for the MT.

According to a second aspect of the present invention, there is provided, an ATM network, adapted to support mobile ATM end points (Mobile Terminals), including a number of Mobile Terminals (MTs); a core network of ATM switches; mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution; at least one mobility enhanced ATM switch (MAS); and an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, n the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability, characterised in that said ATM network includes at least one ATM Roaming Server (RS) adapted to handle location updates for a roaming MT, in that said LS includes a database adapted to store data for each MT, in that said ATM mobile network is adapted to update the database of said LS with the location of a MT when the MT first moves to, and registers with, another network, and in that the database of said at least one ATM RS is adapted to store subsequent location updates for the MT, thereby effecting a reduction in the signalling load on said MT's home network.

The data stored by the database of said LS may include the network address (home network address), current address (visited network address), user profile, including access rights, and location status. The data stored in said LS's database, for each MT, may also include billing information.

The ATM network may include a plurality of ATM RSs and be adapted to dynamically select that one of said plurality of ATM RSs considered by said ATM

network to be best suited, at the particular time, to handle location mobility for a roaming mobile terminal.

According to a third aspect of the present invention, there is provided, in an ATM network, adapted to support mobile ATM end points (Mobile Terminals), said network including a number of Mobile Terminals (Mts); a core network of ATM switches; mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution; at least one mobility enhanced ATM switch (MAS); and an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, on the radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability, a method for handling mobility in the ATM mobile network, characterised by said ATM mobile network providing at least one ATM Roaming Server (RS) for handling location updates for a roaming MT, thereby effecting a reduction in the signalling load on said MT's home network.

The method may be characterised by said at least one ATM RS handling mobility in said ATM network.

The method may characterised by said at least one ATM RS providing a facility that enables a MT to visit, and roam within, another ATM network, without significantly increasing the signalling load on said MT's home network.

The method may be characterised by said at least one ATM RS facilitating inter and intra mobility for access networks that do not have mobility management with location update for roaming MTs.

The method may be characterised by said at least one ATM RS including a database; and by storing, in said database, data relating to a network address for said LS; and mappings between network addresses (home network

addresses) and temporary addresses (visited network addresses) for each of said MTs. This method may be further characterised by storing an address for an authentiThe method may be characterised by each MT including a database; by storing, in the database of each MT, data relating to a network address for an ATM RS with which a respective MT is associated, and the MT's network address (home address), authentication key and access rights; and by stored data relating to a home address including data concerning a MAS, in the MT's home network, with which a respective MT is associated. This method may be further characterised by storing temporary data in the database of each MT, said temporary data including the MT's current address, current LAC and current RP_id.

The method may be characterised by said LS including a database for storing data for each MT; by updating said LS's database with the location of a MT, when the MT first moves (roams) to, and registers with, another network; and by storing subsequent location updates for said roaming MT in the database of said at least one ATM RS.

According to a fourth aspect of the present invention, there is provided, in an ATM network, adapted to support mobile ATM end points (Mobile Terminals), said network including a number of Mobile Terminals (MTs); a core network of ATM switches; mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution; at least one mobility enhanced ATM switch (MAS); and an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, on the radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability, a method for handling mobility in the ATM mobile network, characterised by said ATM mobile network providing at least one ATM Roaming Server (RS) for handling location updates for a roaming MT; by said LS including a database for storing data for each database of said LS with the

location of a MT when the MT first moves to, and registers with, another network; and by storing subsequent location updates for the MT in the database of said at least one ATM RS, thereby effecting a reduction in the signalling load on said MT's home network. The method may be further characterised by storing the following data in said LS's database, for each of said Mts, a network address (home network address); a current address; user profile, including access rights; and location status. The method may be further characterised by storing billing information, for each MT, in the database of said LS.

A method, according to the present invention, for handling location updates in a MT's home network, when said MT first visits another network (visited network), may be characterised by said MT registering with said visited network by transmitting a location update signal to a first MAS of said visited network via a Radio Port (RP) of said first MAS's Access Point (AP); by said first MAS, on receipt of the signal from said MT, sending a location update signal to an ATM RS with which said MT is associated in said home network; by said ATM RS, on receipt of said location update signal: by updating its database with a temporary address for said MT; and by sending a location update signal to said home network's Location Server (LS).

A method, according to the present invention, for handling location updates in a MT's home network, when said MT has registered with a visited network and moves (roams) between first and second MASs in said visited network, may be characterised by said MT having a temporary address, stored in a database thereof, that identifies a network address of an ATM RS with which said MT is associated in its home network; by said MT, on moving from said first to said second MAS, sending a location update signal to said second MAS via a Radio Port (RP) of said second MAS's Access Point (AP); by said second MAS, on reupdate signal to said ATM RS in said home network; and by said ATM RS, on receipt of this information, updating its database with the temporary address for said MT, location update of said home network's LS not being necessary when said MT has been registered with, and is roaming within, said visited

network.

The method may be characterised by said ATM mobile network providing a plurality of ATM RSs for handling location mobility; and by dynamically selecting that one of said plurality of ATM RSs considered by said ATM network to be best suited, at the particular time, to handle location mobility for a roaming MT. The method may be further characterised by said home network being adapted to dynamically redirect incoming location updates, for a roaming MT, from an ATM RS, with which said MT is presently associated in said home network, to another ATM RS best suited to handle location updates for said MT. The method may be further characterised by said roaming MT sending said location update signal, in a manner as claimed in claim 27, or claim 28, from the visited network to said ATM RS in said home network with which said roaming MT is presently associated; by said home network, in response to receipt of said location update signal from said roaming MT, sending said roaming MT a location update reply containing a home network address for use by said roaming MT the next time it sends a location update signal to said home network; and by said home network address, contained in said location update reply, being an address for an ATM RS best suited, at the particular time, to handle location mobility for said roaming MT.

According to a fifth aspect of the present invention, there is provided, a method for setting up a call from a Fixed Terminal (FT) of a PNNI network, without mobility support, to a MT of an ATM mobile network, as outlined in preceding paragraphs, when said MT is visiting another network, characterised by said FT sending a call setup message to a MAS in said home network with which said MT is associated; by said home network MAS, on receipt of said message from said FT, sending an enquiry to said home network's Location Server (LS), concerning the present location of said MT; by said LS, in response to said enquiry, sending said home network MAS the network address of an ATM RS in said home network with which said MT is associated; by said home network MAS, on receipt of the address information, sending a call setup

message to said ATM RS; by said ATM RS, on receipt of the said call setup message, checking its database to find the present address of said MT and, on finding the address, sending a call setup message to a MAS in said visited network with which said MT is currently associated; and, on receipt of said call setup message, by said visited network MAS setting up the call from said FT to said MT.

According to a sixth aspect of the present invention, there is provided, an ATM Roaming Server (RS) for use in either an ATM mobile network, as outlined in preceding paragraphs, or for use in a method as outlined in preceding paragraphs.

The foregoing and other features of the present invention will be better understood from the following description with reference to the accompanying drawings, in which:

Figure 1 diagrammatically illustrates, in the form of a block diagram, a location update arrangement for an ATM mobile network;

Figure 2 diagrammatically illustrates, in the form of a block diagram, call setup for the ATM mobile network of Figure 1; and

Figure 3 diagrammatically illustrates, in the form of a block diagram, a location update arrangement for an ATM mobile network architecture, according to the present invention; and

Figure 4 diagrammatically illustrates, in the form of a block diagram, call setup for the ATM mobile network of Figure 3.

In order to facilitate an understanding of the present invention a glossary of terms used in this patent specification is provided below:

AESA: ATM End System Address

AP: Access Point

ATM: Asynchronous Transfer Mode

AUS: Authentication Server

E-MAS: End user Mobility supporting ATM Switch

ESI: End System Identifier

FT: Fixed Terminal

IP: Internet Protocol

LAC: Local Area Network

LS: Location Server

MAS: Mobility Enhanced ATM Switch

M-PNNI: Mobile PNNI

MT: Mobile Terminal

PCS: Personal Cellular System

PNNI: Private Network to Network Interface

RP_id: Radio Port identification

RS: ATM Roaming Server

TDMA: Time Division Multiple Access

UBR: Unspecified Bite Rate

VBR: Variable Bit rate

VC: Virtual Circuit

VP: Virtual Path

An ATM mobile network architecture is diagrammatically illustrated, in the form of a block diagram, in Figure 1 of the accompanying drawings, and includes two ATM network 1 and 2, each one of which includes a number ATM switches but only one of which, i.e. the network 1, includes mobility management with a Location Server (LS) 3. The mobility management may be a centralized arrangement. The network 1 is the home network for a Mobile Terminal (MT) 4. A Mobile Terminal (MT) is an ATM end point with a mobility capability. With the arrangement of Figure 1, MT 4 is visiting the network 2 and is moving between access switches.

In practice, the Location Server (LS) 3, which is a functional entity consisting of location databases and adapted to provide location resolution, may be implemented in a stand-alone physical entity, or be an integral part of an ATM switch.

The home network 1 and visited network 2 both include a core network of ATM switches, such as the ATM switches 5. The home network 1 also includes a Mobility Enhanced ATM Switch (MAS) 6 having an Access Point (AP) 7 adapted to provide radio connectivity into the switched ATM network. In practice, the home network 1 may include a number of MASs having radio access

capabilities. The visited network 2 includes two Mobility Enhanced ATM switches 8 and 9, respectively having Access Points 10 and 11.

An Access Point (AP) is a device which has:

- on the radio side, one, or more, Radio Ports (RPs); and

- on the network side, an ATM interface and associated signalling channels towards the ATM network with switching capability.

The AP is viewed by the ATM network as a VP (Virtual Path) multiplexer with a number of virtual ports, each port corresponding to a Mobile Terminal (MT) active on one of the Radio Ports.

A Radio Port (RP) is a single logical point providing radio access. In a typical TDMA (Time Division Multiple Access) system, a radio port corresponds to a single TDMA carrier. In the radio environment, each RP can be identified by a unique broadcast identifier.

The data stored in MT 4 includes, inter alia:

- Home Address, i.e. data concerning the access switch with which the MT is associated in its home network;

- Authentication Key; and

- Access Rights.

The Mobile Terminal (MT) 4 may also be adapted to store temporary data, including, inter alia:

- Current LAC;

- Current Address; and

- Current RP_id.

The data stored in Location Server 3, for each Mobile Terminal (MT), includes, inter alia:

- Home Address;

- Current Address;

- User Profile including access rights;

- Location status; and

- Billing Information - this may, in practice, be handled by a separate entity.

Consider the case where MT 4 moves (roams) from its home network 1 and visits network 2 which, as stated above, has no centralized mobile management with a location server facility. Each time MT 4 moves within the visited network 2, i.e. the mobile terminal changes the MAS/AP via which it is connected to the visited network, the Location Server 3 in the home network 1 must be updated in order to ensure that incoming calls to the home network 1, for MT 4, are correctly routed to the mobile terminal. The need to notify the Location Server 3 in the home network 1 of the location of MT 4, each time the access switch is changed in the visited network 2, results in the signal loading in the home network 1 being increased by a significant amount. In other words, a significant signal loading is transferred to the home network 1 each time MT 4 exchanges its access switch in the visited network 2.

The procedure for location update will now be described with reference to

Figure 1, i.e. the procedure for indicating, from a network visited by a MT to the home network of the MT, the actual location of the MS.

Consider the case where MT 4, currently visiting network 2, is accessing the network via a Radio Port (RP) of AP 11 and MAS 9, and moves (roams) within the visited network 2, such that network access is now being obtained via a RP of AP 10 and MAS 8. Since the data stored by MT 4 includes its home address, i.e the address of the access switch, such as MAS 6, with which the MT is associated in its home network, MT 4 is adapted to transmit this information to MAS 8, via a RP of AP 10. On receipt of this information, MAS 8 sends the location update information for MT 4 to the home network, i.e. to the Location Server 3 of the home network 1 via MAS 6. In Figure 1, the location update signals are shown as dotted lines and the connections between the ATM switches are shown as full lines.

In the example ings, the addresses for MT 4 and the Access Switches, are as follows:

- the home network address of MT 4 is 'C.2.1.1';

- the address of MAS 6, i.e. the access switch in the home network with which MT 4 is associated, is 'C.2.1; and

- the address of the access switches, MAS 8 and MAS 9 in the visited network 2 are respectively 'B.3.3' and 'B.3.1';

As illustrated in Figure 1, the location update procedure includes the following steps:

- MT 4 sends a signal 'Loc_Update (C.2.1.1, Authentication data)' to MAS 8 via a RP of AP 10 (see dotted line 12);

- on receipt of the signal from MT 4, MAS 8 sends a signal 'Loc_Update_Home (C.2.1.1, Authentication data, B.3.3)' to MAS 6 (see dotted line 13); and

- MAS, 6, on receipt of the signal from MAS 8, sends a signal 'Loc_Update_LS (C.2.1.1, B.3.3)' to Location Server 3 (see dotted line 14).

The setting up of a call to MT 4 will now be described with reference to Figure 2 of the accompanying drawings. The ATM mobile network architecture of Figure 2 includes the home network 1 and part of the visited network 2 of Figure 1, and a PNNI (Private Network to Network Interface) network 15, without mobility support. The PNNI network of Figure 2 includes a number of ATM switches 16 and a Fixed Terminal (FT) 17 which is a fixed, non-mobility aware, standard ATM end point. The address for FT 17 is 'A.1.1.0'. The PNNI is a protocol specified by the ATM protocol which is used by the switches of an ATM network. Despite its name, PNNI may be used in a public network.

The procedure for handling the setting up of a call, from FT 17 to MT 4, includes the following steps:

- a message 'SETUP(C.2.1.1, A.1.1.0)' is sent (see dotted line 18) from FT 17 to C.2.1 (MAS 6), i.e. the access switch with which MT 4 is associated in its home network 1;

- on receipt of this message, MAS 6 sends an enquiry (see dotted line 19) to LS 3, in the home network 1, concerning the present location of MT 4;

- in response to this enquiry, LS 3 sends (see dotted line 20) MAS 6 the address of the access switch of the visited network 2 with which MT 4 is currently associated - in the present example, the address is 'B.3.3' (MAS 8);

- on receipt of the location information, MAS 6 sends (see dotted line 21) a message 'SETUP(B.3.3, A.1.1.0, C.2.1.1) to MAS 8; and

- on receipt of this message, MAS 8 sets up the call from FT 17 to MT 4 via physical connections between the ATM switches of networks 15, 1 and 2, (including the ATM switches of MAS 6 and MAS 8) and finally by radio communication between a Radio Port (RP) of AP 10 and MT 4, i.e. the route indicated by the solid lines in Figure 2. The detailed procedure for effecting the physical connections is well known to persons skilled in the art and will not, therefore, be addressed by this patent specification.

In accordance with the present invention, the signal loading problems, referred to above, which occur in the home network of a Mobile Terminal (MT) when it visits another network, i.e. roaming, are overcome by using at least one ATM Roaming Server (RS) in the home network. It will be seen from the subsequent description that the use of an ATM Roaming Server (RS) in the home network effectively guards the home network from location updates.

The ATM Roaming Server (RS) of the present invention includes a database in which is stored the address of the home network's Location Server (LS), the mappings between the home addresses and temporary addresses of the Mobile Terminals (MT), and the address of an authentication server. The ATM Roaming Server (RS) is adapted to terminate location updates from a visited network.

In accordance with the present invention, the Location Server (LS) of the home network need only be updated the first time a Mobile Terminal (MT) moves (roams) in a visited network. It is not necessary to update the LS in the home network when the Mobile Terminal (MT) moves from one access switch to an other access switch in the visited network; it is only the ATM Roaming Server (RS) which has to be updated.

The Location Server (LS) 3 in the home network 1 includes a database which stores, inter alia, data for each Mobile Terminal (MT) belonging to the home network. As stated above, the data stored in Location Server 3, for each MT, includes its home address, current address, user profile (including access rights), location status and billing information.

When a MT moves (roams) from its home network to another network (visited network), the LS is updated by the ATM Roaming Server with information regarding the MT's temporary (current) address. The MT stores the address of an ATM Roaming Server (RS), in its home network, with which it is associated, and the temporary address (visited network address) for the MT identifies the address of the associated ATM RS. As stated above, the home network may include more than one ATM RS. The database of the ATM Roaming Server (RS) stores data that indicates the location, in a visited network, where an incoming call to the home network for a MT should be transferred, i.e. the access switch in the visited network to which a call for a MT should be redirected during call setup. This data is transmitted to the ATM Roaming Server (RS) at tion update procedure for the ATM mobile network of the present invention will now be described with reference to Figure 3 of the accompanying drawings.

The only difference between the architecture of the ATM mobile network, diagrammatically illustrated, in the form of a block diagram, in Figure 3, and the network architecture illustrated in Figure 1, is that one of the ATM switches 5 of Figure 1 is replaced, in Figure 3, by an ATM Roaming Server (RS) 22 having the address 'C.1.1'.

When MT 4 moves (roams) from MAS 9 to MAS 8, as illustrated in Figure 3, the location update procedure includes the following steps:

- MT 4 which, as stated above, stores address information for ATM RS 22, sends a signal 'Loc_Update (C.2.1.1, Authentication data, C1.1)' to MAS 8 via a RP of AP 10 (see dotted line 23);

- on receipt of the signal from MT 4, MAS 8 sends a location update signal 'Loc_Update_Home (C.2.1.1, Authentication data, B.3.3)' to ATM RS 22 (see dotted line 24);

- on receipt of this information, ATM RS 22, updates its database, which contains information concerning the home address of MT 4, with the temporary address for MT 4; and

- in the event that the location update information, received from MAS 8, is being sent for the first time, i.e. relates to registration of MT 4 with the visited network, ATM RS 22 sends a signal 'Loc_Update_LS (C.2.1.1, C.1.1)' to LS 3 (see dotted line 25) - this signal is not sent to LS once registration has been effected and MT 4 is roaming within the visited network, i.e. moving from one access switch to another access switch in the visited network.

Thus, when MT 4 first visits another network, for example, visited network 2, the method, according to the present invention, for handling location update in the home network 1, includes the steps of:

- MT 4 registering with the visited network 2 by transmitting a location update signal to MAS 8 of visited network 2 via a Radio Port (RP) of Access Point (AP) 10;

- MAS 8, on receipt of the signal from MT 4, sending a location update signal to ATM RS 22 in the home network 1;

- ATM RS 22, on receipt of the location update signal:

    - updating its database with a temporary address for MT 4; and

- sending a location update signal to the home network's Location Server (LS) 3.

It will be seen from the foregoing description of an ATM mobile network of the present invention that, when a Mobile Terminal (MT) moves (roams) within a visiting network, the location update information is only transmitted to the ATM Roaming Server (RS) to enable the ATM RS to update its database and thereby the mappings between the MT's home address and temporary address. With this arrangement, there is no need to update the home network's Location Server (LS), thereby effecting a reduction in the signalling load on the MT's home network. In other words, in the absence of an ATM RS, each location update for a MT, received by a MAS with which the MT is associated in its home network, would have to be sent to the home network's Location Server (LS), whereas the use of an ATM RS guards the home network from location updates, i.e. it is only necessary to update the database of the LS when a roaming MT first registers with a visited network.

The setting up of a call from a Fixed Terminal (FT) to a Mobile Terminal (MT), using an ATM Roaming Server (RS), will now be described with reference to Figure 4 of the accompanying drawings. The ATM mobile network architecture of Figure 4 includes the home network 1 and part of the visited network 2 of Figure 3, and the PNNI (Private Network to Network Interface) network 15, without mobility support, of Figure 2 of the accompanying drawings. As with Figure 2, the address for the Fixed Terminal (FT) 17 of Figure 4 is 'A.1.1.0'.

The procedure for handling the setting up of a call, from FT 17 to MT 4, is illustrated in Figure 4 and includes the following steps:

- a message 'SETUP(C.2.1.1, A.1.1.0)' is sent (see dotted line 26) from FT 17 to C.2.1 (MAS 6), i.e. the access switch with which MT 4 is associated in its home network 1;

- on receipt of this message, MAS 6 sends an enquiry (see dotted line 27) to LS 3, in the home network 1, concerning the present location of MT 4;

- in response to this enquiry, LS 3 sends (see dotted line 28) MAS 6 the address of the ATM RS 22 - in the present example, the address is 'C.1.1';

- on receipt of the address information, MAS 6 sends (see dotted line 29) a message 'SETUP(C.1.1, A.1.1.0, C.2.1.1) to ATM RS 22; and

- on receipt of this message, ATM RS 22 checks its database to determine the present address of MT 4 - in the present example, the address for MT 4 is 'B.3.3' (MAS 8);

- ATM RS 22 sends (see dotted line 30) a call setup message 'SETUP(B.3.3, A.1.1.0, C.2.1.1) to MAS 8; and

- on receipt of this message, MAS 8 sets up the call from FT 17 to MT 4 via the physical connections between the ATM switches of networks 15, 1 and 2, (including the ATM switches of MAS 6 and ATM Roamer Server 22) and finally by radio communication between a Radio Port (RP) of AP 10 and MT 4, i.e. the route indicated by the solid lines in Figure 2. The detailed procedure for effecting the physical connections is well known to persons skilled in the art and will not, therefore, be addressed by this patent specification.

Although the ATM mobile network of the present invention has been described in relation to a single ATM Roaming Server (RS), the home network may, in practice, use a number of these servers. Each of the Mobile Terminals, associated with the home network, stores address information for the ATM Roaming Server (RS) to which location updates should be sent.

In some instances, an ATM Roaming Server, with which a roaming mobile terminal is associated in its home network may not be suitably located with respect to the ATM network being visited by the mobile terminal. As a consequence of this, the ATM mobile network of the present invention is adapted to provide a dynamic, and more optimal way, of using ATM Roaming Servers. In essence, the only information a mobile terminal needs to have, in advance of visiting another ATM network, is an address to an ATM Roaming Server, or another entity with the same functionality, in the home network

Thus, an ATM mobile network of the present invention is adapted to dynamically point out which of a number of ATM Roaming Server is the most suitable server to use. The ability to select the most suitable ATM Roaming Server increases the functionality of the ATM mobile network.

The dynamic selection of the most suitable ATM Roaming Server (ATM RS) is effected by the mobile terminal, MT 4, announcing its new location in accordance with the following method:

(1) The mobile terminal, MT 4, sends a Location Update signal, in a manner as outlined above for location updates, from the visited network to the ATM Roaming Server with which it is associated in the home network.

(2) In response to receipt of the Local Update signal, the home network sends MT 4 a 'Location Update Reply' signal containing a home network address for use by MT 4 the next time it sends a Location Update signal to the home network.

(3) The home network address to which MT 4 must send the next Location Update signal, is an address for an ATM RS considered by the home network to be the most suitable, at the particular time, for handling location updates for MT 4.

It will be seen from the foregoing that the method for dynamically selecting an ATM RS is:

- for use in association with a home network having a number of ATM RSs; and

- is adapted to redirect incoming location updates, for a roaming mobile terminal, from an ATM RS, with which the mobile terminal is presently associated in the home network, to a new ATM RS by sending the roaming mobile terminal, in response to a Location Update signal, an address for a new ATM RS.

It will be directly evident to persons skilled in the art that the ATM Roaming Server (RS) of the present invention can be used in a number of applications, for example, such a server can be used for handling mobility in ATM systems, for instance, it can be used in systems to provide the means to enable ATM terminals to visit another network without introducing a large signalling load on the home network of the ATM terminals.

The ATM Roaming Server is also adapted to facilitate inter and intra mobility for access networks that do not have their own location servers. For example, the ATM Roaming Server could be used in the case where Telia connects private ATM wireless ATM access networks and the mobility is managed within Telia's public network.

CLAIMS

1. An ATM network, adapted to support mobile ATM end points (Mobile Terminals), including a number of Mobile Terminals (MTs); a core network of ATM switches; mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution; at least one mobility enhanced ATM switch (MAS); and an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, on the radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability, characterised in that said ATM network includes at least one ATM Roaming Server (RS) adapted to handle location updates for a roaming MT, thereby effecting a reduction in the signalling load on said MT's home network.

2. An ATM mobile network, as claimed in claim 1, characterised in that said at least one ATM RS is adapted to handle mobility in said ATM network.

3. An ATM mobile network, as claimed in claim 1, characterised in that said at least one ATM RS is adapted to enable a MT to visit, and roam within, another ATM network, without significantly increasing the signalling load on said MT's

home network.

4. An ATM mobile network, as claimed in claim 1, characterised in that said at least one ATM RS is adapted to facilitate inter and intra mobility for access networks that do not have mobility management with location update for roaming MTs.

5. An ATM mobile network, as claimed in any preceding claim, characterised in that said at least one ATM RS includes an ATM switch having a location server associated therewith.

6. An ATM mobile network, as claimed in any preceding claim, characterised in that said at least one ATM RS includes a database adapted to store a network address for said LS, and mappings between network addresses (home addresses) and temporary addresses (visited network addresses) for each of said MTs.

7. An ATM mobile network, as claimed in claim 6, characterised in that said database of said at least one ATM RS is adapted to store an address of an authentication server.

8. An ATM mobile network, as claimed in any preceding claim, characterised in that each MT includes a database adapted to store data relating to a network address for an ATM RS with which a respective MT is associated, and the MT's network address (home address), authentication key and access rights, and in that said home address includes data concerning a MAS, in the MT's home network, with which the MT is associated.

9. An ATM mobile network, as claimed in claim 8, characterised in that said database of each MT is adapted to store temporary data, including the MT's current address, current LAC and current RP_id.

10. An ATM mobile network, as claimed in any preceding claim, characterised in that said LS includes a database adapted to store data for each MT, and in that said network is adapted to update the database of said LS with the location of a MT when the MT first moves to, and registers with, another network, the database of said at least one ATM RS being adapted to store subsequent location updates for the MT.

11. An ATM network, adapted to support mobile ATM end points (Mobile Terminals), including a number of Mobile Terminals (MTs); a core network of ATM switches; mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution; at least one mobility enhanced ATM switch (MAS); and an Access Point (AP) for said at least one MAS, said AP being adapted to prothe radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability, characterised in that said ATM network includes at least one ATM Roaming Server (RS) adapted to handle location updates for a roaming MT, in that said LS includes a database adapted to store data for each MT, in that said ATM mobile network is adapted to update the database of said LS with the location of a MT when the MT first moves to, and registers with, another network, and in that the database of said at least one ATM RS is adapted to store subsequent location updates for the MT, thereby effecting a reduction in the signalling load on said MT's home network.

12. An ATM mobile network, as claimed in claim 10, or claim 11, characterised in that data stored by the database of said LS includes the network address (home network address), current address (visited network address), user profile, including access rights, and location status.

13. An ATM mobile network, as claimed in claim 12, characterised in that data stored in said LS's database, for each MT, includes billing information.

14. An ATM network, as claimed in any of claims 1 to 13, characterised in that said ATM network includes a plurality of ATM RSs and is adapted to dynamically select that one of said plurality of ATM RSs considered by said ATM network to be best suited, at the particular time, to handle location mobility for a roaming mobile terminal.

15. In an ATM network, adapted to support mobile ATM end points (Mobile Terminals), said network including:

- a number of Mobile Terminals (MTs);

- a core network of ATM switches;

- mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution;

- at least one mobility enhanced ATM switch (MAS); and

- an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, on the radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability;

a method for handling mobility in the ATM mobile network, characterised by said ATM mobile network providing at least one ATM Roaming Server (RS) for handling location updates for a roaming MT, thereby effecting a reduction in the signalling load on said MT's home network.

16. A method, as claimed in claim 15, characterised by said at least one ATM RS handling mobility in said ATM network.

17. A method, as claimed in claim 15, characterised by said at least one ATM RS providing a facility that enables a MT to visit, and roam within, another ATM network, without significantly increasing the signalling load on said MT's home network.

18. A method, as claimed in claim 15, characterised by said at least one ATM RS facilitating inter and intra mobility for access networks that do not have mobility management with location update for roaming MTs.

19. A method, as claimed in any of claims 15 to 18, characterised by:

- said at least one ATM RS including a database; and
- storing, in said database, data relating to:
  - a network address for said LS; and
  - mappings between network addresses (home network addresses) and temporary addresses (visited network addresses) for each of said MTs.

20. A method, as claimed in claim 19, characterised by storing an address for an authentication server in said database of said at least one ATM RS.

21. A method, as claimed in any of claims 15 to 20, characterised by:

- each MT including a database; and
- storing, in the database of each MT, data relating to:
  - a network address for an ATM RS with which a respective MT is

associated; and

- the MT's network address (home address), authentication key and access rights;

stored data relating to a home address including data concerning a MAS, in the MT's home network, with which a respective MT is associated.

22. A method, as claimed in claim 21, characterised by storing temporary data in the database of each MT, said temporary data including the MT's current address, current LAC and current RP_id.

23. A method, as claimed in any of claims 15 to 22, characterised by:

- said LS including a database for storing data for each MT;

- updating said LS's database with the location of a MT, when the MT first moves (roams) to, and registers with, another network; and

- storing subsequent location updates for said roaming MT in the database of said at least one ATM RS.

24. In an ATM network, adapted to support mobile ATM end points (Mobile Terminals), said network including:

- a number of Mobile Terminals (MTs);

- a core network of ATM switches;

- mobility management means including a Location Server (LS), said LS including a location database for said MTs and being adapted to provide location resolution;

- at least one mobility enhanced ATM switch (MAS); and

- an Access Point (AP) for said at least one MAS, said AP being adapted to provide radio connectivity between a MT and said ATM network and having, on the radio side thereof, at least one radio port and, on the network side thereof, an ATM interface and associated signalling channels, towards said at least one MAS, with switching capability;

a method for handling mobility in the ATM mobile network, characterised by:

- said ATM mobile network providing at least one ATM Roaming Server (RS) for handling location updates for a roaming MT;

- said LS including a database for storing data for each MT;

- said ATM mobile network updating the database of said LS with the location of a MT when the MT first moves to, and registers with, another network; and

- storing subsequent location updates for the MT in the database of said at least one ATM RS, thereby effecting a reduction in the signalling load on said MT's home network.

25. A method, as claimed in claim 23, or claim 24, characterised by storing the following data in said LS's database, for each of said MTs:

- a network address (home network address);

- a current address;

- user profile, including access rights; and

- location status.

26. A method, as claimed in claim 25, characterised by storing billing information, for each MT, in the database of said LS.

27. A method, as claimed in any of claims 15 to 26, for handling location updates in a MT's home network, when said MT first visits another network (visited network), characterised by:

- said MT registering with said visited network by transmitting a location update signal to a first MAS of said visited network via a Radio Port (RP) of said first MAS's Access Point (AP);

- said first MAS, on receipt of the signal from said MT, sending a location update signal to an ATM RS with which said MT is associated in said home network;

- said ATM RS, on receipt of said location update signal:

  - updating its database with a temporary address for said MT; and

  - sending a location update signal to said home network's Location Server (LS).

28. A method, as claimed in any of claims 15 to 26, for handling location updates in a MT's home network, when said MT has registered with a visited network and moves (roams) between first and second MASs in said visited network, characterised by:

- said MT having a temporary address, stored in a database thereof, that identifies a network address of an ATM RS with which said MT is

associated in its home network;

- said MT, on moving from said first to said second MAS, sending a location update signal to said second MAS via a Radio Port (RP) of said second MAS's Access Point (AP);

- said second MAS, on receipt of the signal from said MT, sending a location update signal to said ATM RS in said home network; and

- said ATM RS, on receipt of this information, updating its database with the temporary address for said MT, location update of said home network's LS not being necessary when said MT has been registered with, and is roaming within, said visited network.

29. A method, as claimed in any of claims 15 to 28, characterised by:

- said ATM mobile network providing a plurality of ATM RSs for handling location mobility; and

- dynamically selecting that one of said plurality of ATM RSs considered by said ATM network to be best suited, at the particular time, to handle location mobility for a roaming MT.

30. A method, as claimed in claim 29, when appended to either claim 27, or claim 28, characterised by said home network being adapted to dynamically redirect incoming location updates, for a roaming MT, from an ATM RS, with which said MT is presently associated in said home network, to another ATM RS best suited to handle location updates for said MT.

31. A method, as claimed in claim 30, characterised by:

- said roaming MT sending said location update signal, in a manner as

claimed in claim 27, or claim 28, from the visited network to said ATM RS in said home network with which said roaming MT is presently associated;

- said home network, in response to receipt of said location update signal from said roaming MT, sending said roaming MT a location update reply containing a home network address for use by said roaming MT the next time it sends a location update signal to said home network; and

- said home network address, contained in said location update reply, being an address for an ATM RS best suited, at the particular time, to handle location mobility for said roaming MT.'

32. A method for setting up a call from a Fixed Terminal (FT) of a PNNI network, without mobility support, to a MT of an ATM mobile network, as claimed in any of claims 1 to 14, when said MT is visiting another network, characterised by:

- said FT sending a call setup message to a MAS in said home network with which said MT is associated;

- said home network MAS, on receipt of said message from said FT, sending an enquiry to said home network's Location Server (LS), concerning the present location of said MT;

- said LS, in response to said enquiry, sending said home network MAS the network address of an ATM RS in said home network with which said MT is associated;

- said home network MAS, on receipt of the address information, sending a call setup message to said ATM RS;

- said ATM RS, on receipt of the said call setup message, checking its

database to find the present address of said MT and, on finding the address, sending a call setup message to a MAS in said visited network with which said MT is currently associated; and

- on receipt of said call setup message, said visited network MAS setting up the call from said FT to said MT.

33. An ATM Roaming Server (RS) for use in either an ATM mobile network, as claimed in any of claims 1 to 14, or for use in a method as claimed in any of claims 15 to 31.

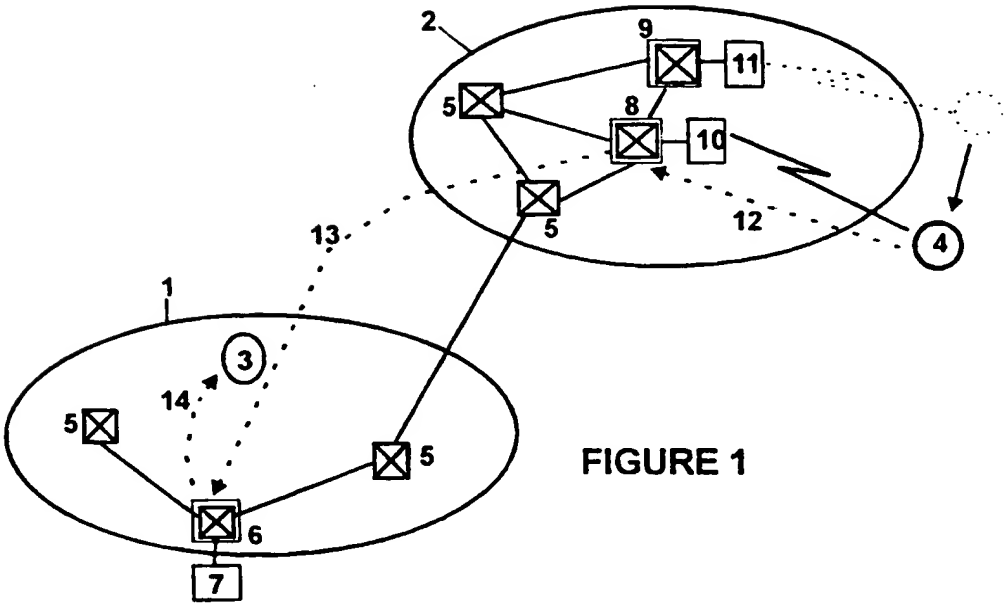

FIGURE 1

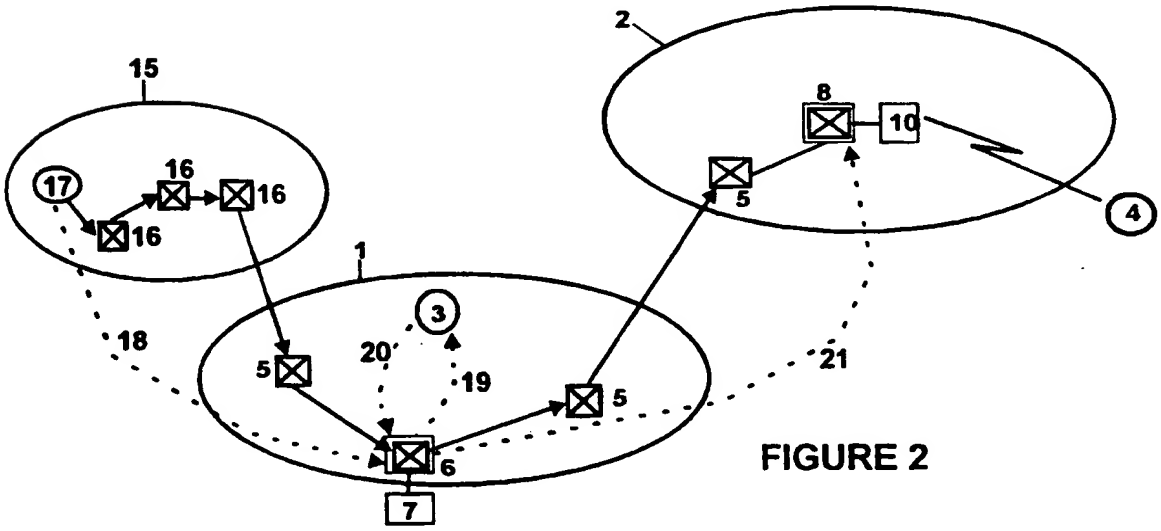

FIGURE 2

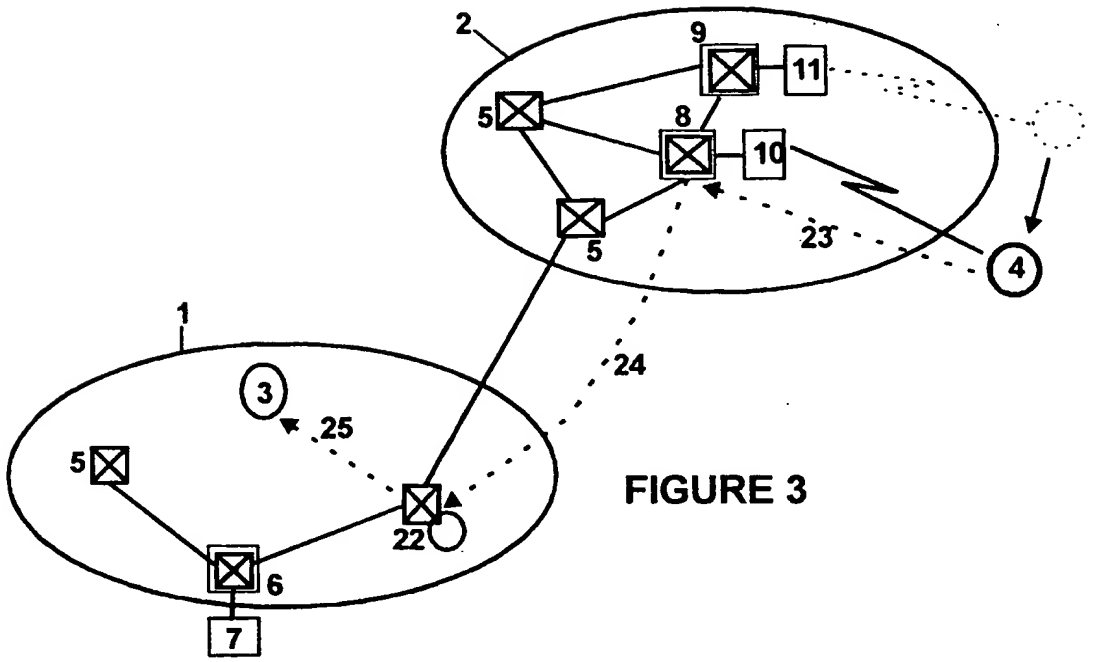

FIGURE 3

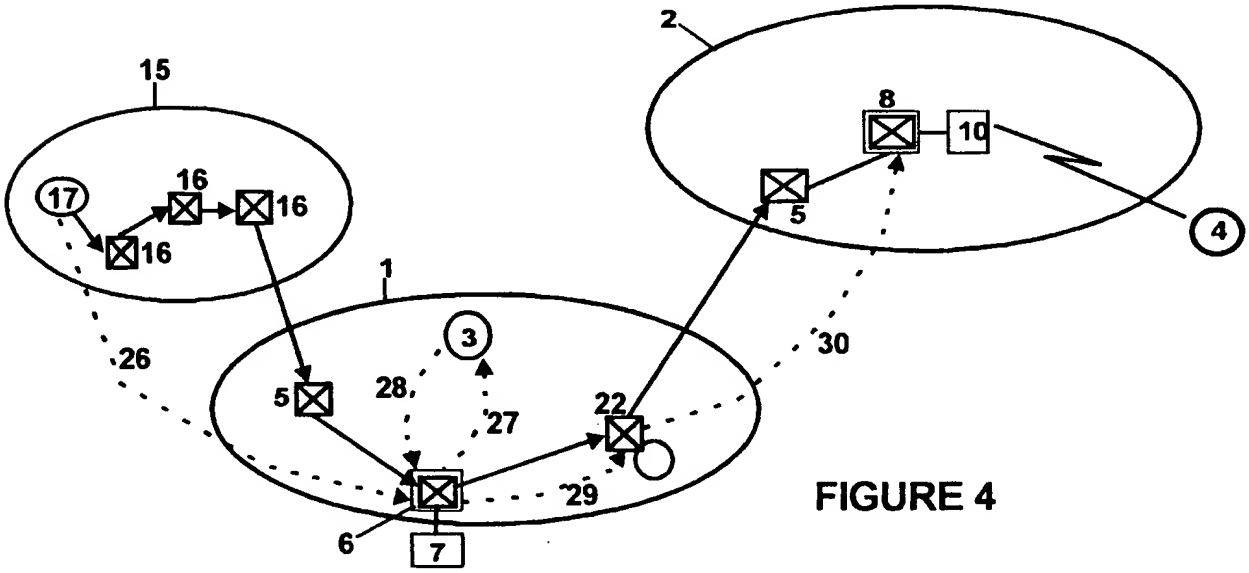

FIGURE 4